CLAIMS

What is claimed is:

1. A hybrid battery power source for implantable medical use, comprising:

a primary battery;

a secondary battery connected to receive power from said primary battery;

said secondary battery being adapted to power to an implantable medical device designed for high energy electrical stimulation of body tissue for therapeutic purposes; and

a charge control circuit powered by said primary battery and including voltage reference and window comparator means for charging said secondary battery while limiting charge/discharge excursions thereof in a manner that optimizes its output for high energy medical device use.

2. A hybrid battery power source in accordance with Claim 1 wherein said charge control circuit is a pulse output circuit adapted for variable pulse width or duty cycle control, thereby allowing it to operate over a range of voltages output by said primary battery.

3. A hybrid battery power source in accordance with Claim 1 wherein said charge control circuit is adapted to charge said secondary battery over a charge/discharge excursion range that is below a maximum state-of-charge of said secondary battery and which is selected to control discharge capacity fade and internal resistance increase during service of said secondary battery.

4. A hybrid battery power source in accordance with Claim 1 wherein said voltage reference and window comparator means includes first and second voltage comparators, said first voltage comparator being adapted to initiate charging when said secondary battery falls below a minimum voltage provided by a first voltage reference and said second voltage comparator being adapted to terminate charging when said secondary battery is charged to a maximum voltage provided by a second voltage reference.

5. A hybrid battery power source in accordance with Claim 4 further including a pulse generator powered by said primary battery, said pulse generator being adapted to supply

pulsatile power to said first and second voltage comparators and said first and second voltage references in order to conserve energy supplied by said primary battery to said charge control circuit.

6. A hybrid battery power source in accordance with Claim 1 wherein said primary battery is selected from the group consisting of lithium-carbon monofluoride batteries, lithium-bromine chloride batteries, lithium-sulfuryl chloride batteries, lithium thionyl chloride batteries, lithium-manganese dioxide batteries, lithium-silver vanadium oxide batteries and lithium-iodide batteries, and wherein said secondary battery is selected from the group consisting of lithium-ion batteries.

7. A hybrid battery power source in accordance with Claim 1 further including a voltage boost circuit that facilitates charging of said secondary battery at a voltage that is higher than a voltage output of said primary battery.

8. A hybrid battery power source in accordance with Claim 7 wherein said voltage boost circuit comprises one of an inductive element or flyback transformer.

9. A hybrid battery power source in accordance with Claim 7 wherein said voltage boost circuit comprises a capacitive charge storage device.

10. A hybrid battery power source in accordance with Claim 9 wherein said voltage boost circuit is adapted to produce charging pulses of sufficiently short duration to reduce the discharge rate of said primary battery to a level that is compatible with the maximum discharge current capacity thereof.

11. An implantable medical device for high energy electrical stimulation of body tissue for therapeutic purposes, comprising:

a pair of electrical contacts adapted to provide electrical stimulation to body tissue;

energy storage means adapted to provide electrical energy to said electrical contacts;

switching means adapted to periodically interconnect said energy storage means to said electrical contacts; and

a hybrid battery power source adapted to provide power to said energy storage means and including:

a primary battery;

a secondary battery connected to receive power from said primary battery and to provide power to said energy storage means; and

a charge control circuit powered by said primary battery and including voltage reference and window comparator means for charging said secondary battery while limiting charge/discharge excursions thereof in a manner that optimizes its output for high energy medical device use.

12. An implantable medical device in accordance with Claim 11 wherein said charge control circuit is a pulse output circuit adapted for variable pulse width or duty cycle control, thereby allowing it to operate over a range of voltages output by said primary battery.

13. An implantable medical device in accordance with Claim 11 wherein said charge control circuit is adapted to charge said secondary battery over a charge/discharge excursion range that is below a maximum state-of-charge of said secondary battery and which is selected to control discharge capacity fade and internal resistance increase during service of said secondary battery.

14. An implantable medical device in accordance with Claim 11 wherein said voltage reference and window comparator means includes first and second voltage comparators, said first voltage comparator being adapted to initiate charging when said secondary battery falls below a minimum voltage provided by a first voltage reference and said second voltage comparator being adapted to terminate charging when said secondary battery is charged to a maximum voltage provided by a second voltage reference.

15. An implantable medical device in accordance with Claim 14 further including a pulse generator powered by said primary battery, said pulse generator being adapted to supply pulsatile power to said first and second voltage comparators and said first and second voltage references in order to conserve energy supplied by said primary battery to said charge control circuit.

16. An implantable medical device in accordance with Claim 11 wherein said primary battery is selected from the group consisting of lithium-carbon monofluoride batteries, lithium-bromine chloride batteries, lithium-sulfuryl chloride batteries, lithium thionyl chloride batteries, lithium-manganese dioxide batteries, lithium-silver vanadium oxide batteries and lithium-iodide batteries, and wherein said secondary battery is selected from the group consisting of lithium-ion batteries.

17. An implantable medical device in accordance with Claim 11 further including a voltage boost circuit that facilitates charging of said secondary battery at a voltage that is higher than a voltage output of said primary battery.

18. An implantable medical device in accordance with Claim 17 wherein said voltage boost circuit comprises one of an inductive element or flyback transformer.

19. An implantable medical device in accordance with Claim 17 wherein said voltage boost circuit comprises a capacitive charge storage device.

20. An implantable medical device in accordance with Claim 19 wherein said voltage boost circuit is adapted to produce charging pulses of sufficiently short duration to reduce the discharge rate of said primary battery to a level that is compatible with the maximum discharge current capacity thereof.

21. A method for powering an implantable medical device designed for high energy electrical stimulation of body tissue for therapeutic purposes, comprising:

providing a primary battery;

providing a secondary battery and connecting it to receive power from said primary power battery;

connecting said secondary battery to power said implantable medical device;

periodically monitoring the charge state of said secondary battery; and

periodically charging said secondary battery by way of said primary battery while limiting charge/discharge excursions of said secondary battery in a manner that optimizes its output for high energy medical device use.

22. A method in accordance with Claim 21 wherein said charging is performed under variable pulse width or duty cycle control over a range of voltages output by said primary battery.

23. A method in accordance with Claim 21 wherein said charging comprises charging said secondary battery over a charge/discharge excursion range that is below a maximum state-of-charge of said secondary battery and which is selected to control discharge capacity fade and internal resistance increase during service of said secondary battery

24. A method in accordance with Claim 21 wherein said monitoring comprising a first periodic comparison to initiate charging when said secondary battery falls below a minimum voltage and a second periodic comparison to terminate charging when said secondary battery is charged to a maximum voltage.

25. A method in accordance with Claim 24 wherein said first and second comparisons are performed using pulsatile energy delivered by said primary battery in order to conserve energy supplied by said primary battery for said first and second comparisons.

26. A method in accordance with Claim 21 wherein said primary battery is selected from the group consisting of lithium-carbon monofluoride batteries, lithium-bromine chloride batteries, lithium-sulfuryl chloride batteries, lithium thionyl chloride batteries, lithium-manganese dioxide batteries, lithium-silver vanadium oxide batteries and lithium-iodide

batteries, and wherein said secondary battery is selected from the group consisting of lithium-ion batteries.

27. A method in accordance with Claim 21 further including voltage boosting in order to charge said secondary battery at a voltage that is higher than a voltage output of said primary battery.

28. A method in accordance with Claim 27 wherein said voltage boosting comprises inductive voltage boosting.

29. A method in accordance with Claim 27 wherein said voltage boosting comprises capacitive voltage boosting.

30. A method in accordance with Claim 29 wherein said voltage boosting comprises producing charging pulses of sufficiently short duration to reduce the discharge rate of said primary battery to a level that is compatible with the maximum discharge current capacity thereof.